A lighthouse radiation detector is named for its sweeping and scanning field of view, which comes from all but one side being shielded, in this case with tungsten plates, to attenuate the detection of gamma rays. The location of a radiation source is determined by comparing the changing signal strength as the detector pivots, "looking" around the room.

SPOTLIGHTS

Radiation Detection Gets Direction

Scientists at Los Alamos recently learned something that they already knew: The ground at the Trinity site in south-central New Mexico is still radioactive. But not terribly so—eating a banana will deliver about as much ionizing radiation as 20 minutes at Trinity, where the first atomic bomb test was conducted. Further, the soil contains two kinds of radiation sources: direct decay products left over from the 1945 blast and elements native to the soil that were induced to radioactivity after capturing free neutrons released by the test. But while the radioactivity itself is not new, the way in which it was measured is.

Los Alamos engineer Jonathan Dowell has invented a suite of novel radiation detectors. Conventional radiation detectors operate on proximity—the closer the source, the stronger the signal—so pinpointing a source is a literal game of "hot-and-cold." But Dowell's detectors, which he named "lighthouse detectors" based on their sweeping and scanning field of view, are more sophisticated. They can pinpoint the direction of a radiation source without having to approach it and distinguish between sources when multiple sources are present, offering improvements to both safety and speed of material inventories, geological surveys, or radiological remediation. The survey at Trinity used a HAZMAT robot outfitted with lighthouse detectors and was a successful demonstration of how quickly large areas can be surveyed without sending in any people.

A self-described Ozark mountain hillbilly, Dowell was a teenaged ham radio operator. In 1989 he came to northern New Mexico for the skiing, stayed for the love of a lady, and in the meantime built an impressive engineering career at Los Alamos. In 2012, while surveying a contaminated glovebox, Dowell, being familiar with the directional nature of radio antennae, wished for a similarly directional radiation detector to pinpoint exactly which part of the glovebox was hottest. No such detector existed, so he invented one.

Similar devices block the radiation on all sides except one. But fully blocking gamma rays or fast neutrons requires a lot of bulky shielding material. What Dowell did differently, to keep his detectors small and agile, was to focus on attenuation, or reducing the signal, rather than trying to block it completely. Dowell likens it to a car with tinted windows—sunlight still enters through the rear and side windows but is attenuated, while the sunlight entering through the untinted windshield is not. Attenuated signals can be compared to unattenuated signals either through space—multiple detectors in different orientations to the source—or through time—one detector with a rotating field of view that intermittently points toward a source.

The gamma-ray lighthouse detectors consist of solid scintillator crystals surrounded on all but one side by attenuating tungsten plates. The fast-neutron lighthouse detectors consist of long narrow tubes filled with helium-3 gas and partially wrapped with an attenuating custom boron-carbide ceramic. At the back of each sits the electronics package, which is basically a small computer, including a power supply, signal processer, spectrometer, and web server, with both USB and Ethernet connectivity.

"The means by which we detect radiation is not new technology," Dowell explains. "We advanced the engineering mainly through custom electronics. That's how we got the detectors to be so versatile and portable."

After proving the efficacy of his prototypes in 2012, Dowell and Los Alamos teamed up with several industrial partners to miniaturize and refine the physical designs. In 2015 the team demonstrated undersea capabilities of lighthouse detectors arrayed aboard a remotely operated submarine vehicle. Then, after further miniaturization—in three months the electronics package went from the size of a lunch box to half the size of a business card—the detectors were ready for mass production, enabling a myriad of remote field capabilities.

The safety benefit of lighthouse detectors for automated mapping of complex sites is twofold. First, the time and amount of exposure are minimized because the detectors can quickly zero-in on the location of a source. Second, dangerous tasks—like entering a site after an event, which can include physical instability, cumbersome maneuvering in radiation suits, and eventual fatigue—can be exchanged for less dangerous tasks, like sitting in a control booth a safe and comfortable distance away, controlling a HAZMAT robot carrying lighthouse detectors.

In keeping with the noble job of their namesake, lighthouse detectors cast their gaze into the darkness, helping to keep people out of harm's way.

—Eleanor Hutterer

Megapower

Imagine an electrical power plant small enough to be delivered by truck, simple enough to be fully operational in a few days, and energetic enough to power a small town for a decade or more without refueling. It can provide electricity to remote communities, hardware installations, and deployed military bases. It can protect critical infrastructure like hospitals from reliance on the electrical grid. It runs with minimal moving parts, continuously self-regulates to match changing electrical demand, and produces zero greenhouse-gas emissions. It's coming soon to the places that need it. But where does it come from?

Mars.

Working in partnership with NASA, Los Alamos scientists recently unveiled Kilopower: a small, fully automated nuclear power plant designed to operate continuously for decades on deep-space craft, on the moon, or on Mars—providing abundant and secure power for human exploration or colonization. [*See "Power to the Planet" in the August 2018 issue of* 1663.] But in an unusual twist, instead of just adapting an existing technology for use in space, the scientists went on to scale up the space technology for use on Earth. Because Kilopower was already designed to work safely and reliably in an exceedingly hostile and remote environment, it was a natural model for safe, reliable, and especially portable power for sensitive or remote locales here at home.

Thus, Megapower was born. Like its space-worthy predecessor, Megapower employs an entirely new kind of nuclear reactor, in which several pieces of specially arranged solid uranium undergo a fission chain reaction. The reaction generates heat (instead of, say, burning coal or gasoline), and that heat is delivered to an engine by a Los Alamos invention called a heat pipe. Whenever more power is needed, the heat pipe draws heat faster, cooling the reactor and therefore slightly shrinking the uranium. With the fissionable fuel now denser, the neutrons causing the chain reaction naturally encounter more nuclei to split, thus increasing the reaction rate; in this way, the reactor automatically increases power when it's needed and, conversely, cuts power when it's not.

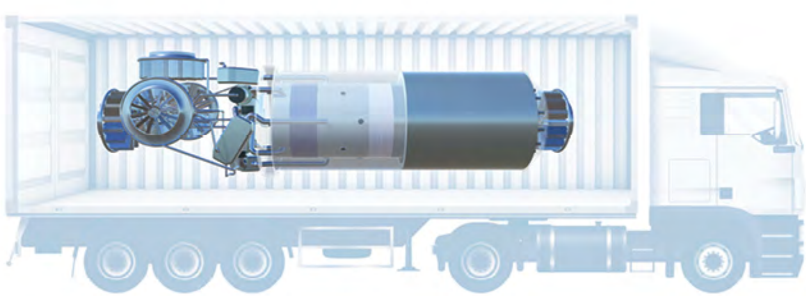
This self-regulation also acts as a built-in safety guarantee. A conventional nuclear power plant constantly operates a network of valves and pumps to pipe in vast quantities of water from a nearby lake or river to cool the reactor; these components can potentially fail in an emergency. But Megapower is self-cooling; it requires no water and no specific safety subsystems to secure the reactor. Runaway reactions, such as those that might lead to a meltdown, are simply not possible because the reaction rate is always limited by the fact that rising temperature expands the solid fuel, thereby putting the brakes on the reaction.

Los Alamos has partnered with Westinghouse, a major producer of nuclear (and nonnuclear) power plants, to refine the design and manufacture the plants under the name eVinci™. For safety, reliability, portability, and ease-of-use that's sufficient for operation on another planet, it will have the Los Alamos-designed reactor core and heat-pipe systems. For efficiency and economy appropriate to Earth-bound applications, it will have a Westinghouse engine-generator system to convert reactor heat into electricity.

The unit is designed to be modular and produce about 10 megawatts of electricity. That's on the order of one hundredth of the maximum power output of a large nuclear power plant—plenty for a small town or remote research facility, such as a cluster of mountaintop observatories. A modest city like Santa Fe, New Mexico, with a residential population of 150,000, would probably require five to ten units. However, because Megapower is designed to sacrifice economy of scale in favor of versatility, the electricity would be somewhat more expensive than typical grid-based power. Therefore, the technology would be better suited for isolated and specialized applications requiring significant uninterrupted power than for existing grid-connected cities.

The Los Alamos team is currently maturing designs, testing materials, and exploring manufacturing options, with component and systems testing not far behind. If all goes according to plan, then anyone looking to retire off-grid with ten thousand households' worth of stable, automated power (and, not for nothing, a security perimeter suitable for safeguarding uranium) could see the ideal technology come online in as little as five years. LDRD

—Craig Tyler



Megapower—a small self-regulating, carbon-free, standalone power plant—will fit in a standard shipping container for transport by road, rail, air, or sea.